

INTEGRATED MONITORING SYSTEMS FOR STRUCTURAL ASSESSMENT

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AIM

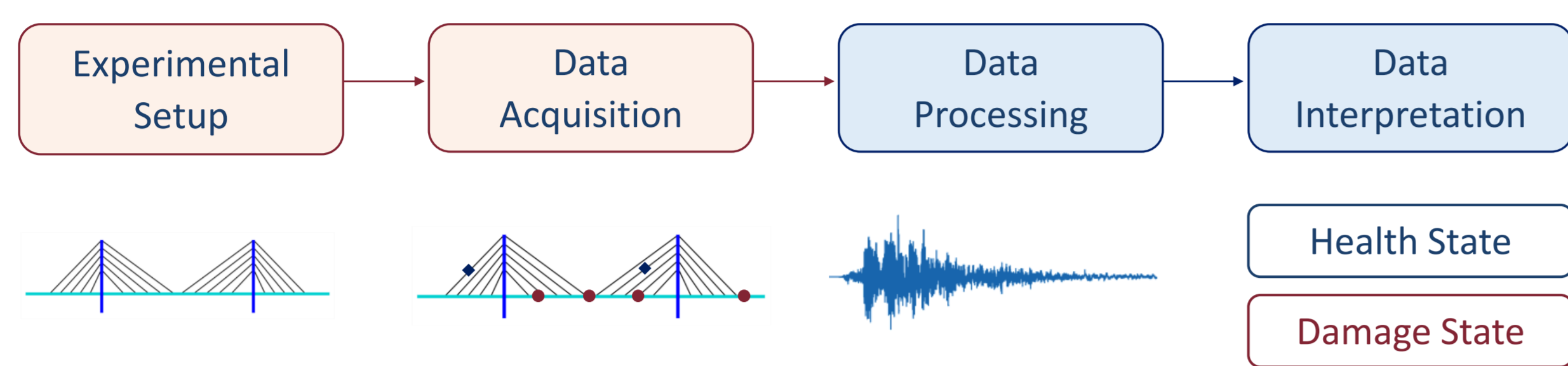
Structural Health Monitoring (SHM) refers to the process of evaluating the health state of a structure through the **elaboration of recorded data**.

SHM approaches have been in constant evolution for decades thanks to advances in sensing technology and computational capabilities. Recent structural collapses around the world stressed out the necessity of having monitoring systems able to identify the health state of structures, particularly the ones that have strategic importance or historic value.

The installation of sensors on historic structures can sometimes be difficult and, to overcome some of the limitations of traditional systems, the research community is recently exploring **new technologies** based on **image processing** and **computer vision**. The main advantages of these approaches rely on the possibility of **high-density measurements** and a relatively **simple acquisition process**, for which neither an expensive equipment nor advanced technical skills are mandatorily required.

METHODOLOGY

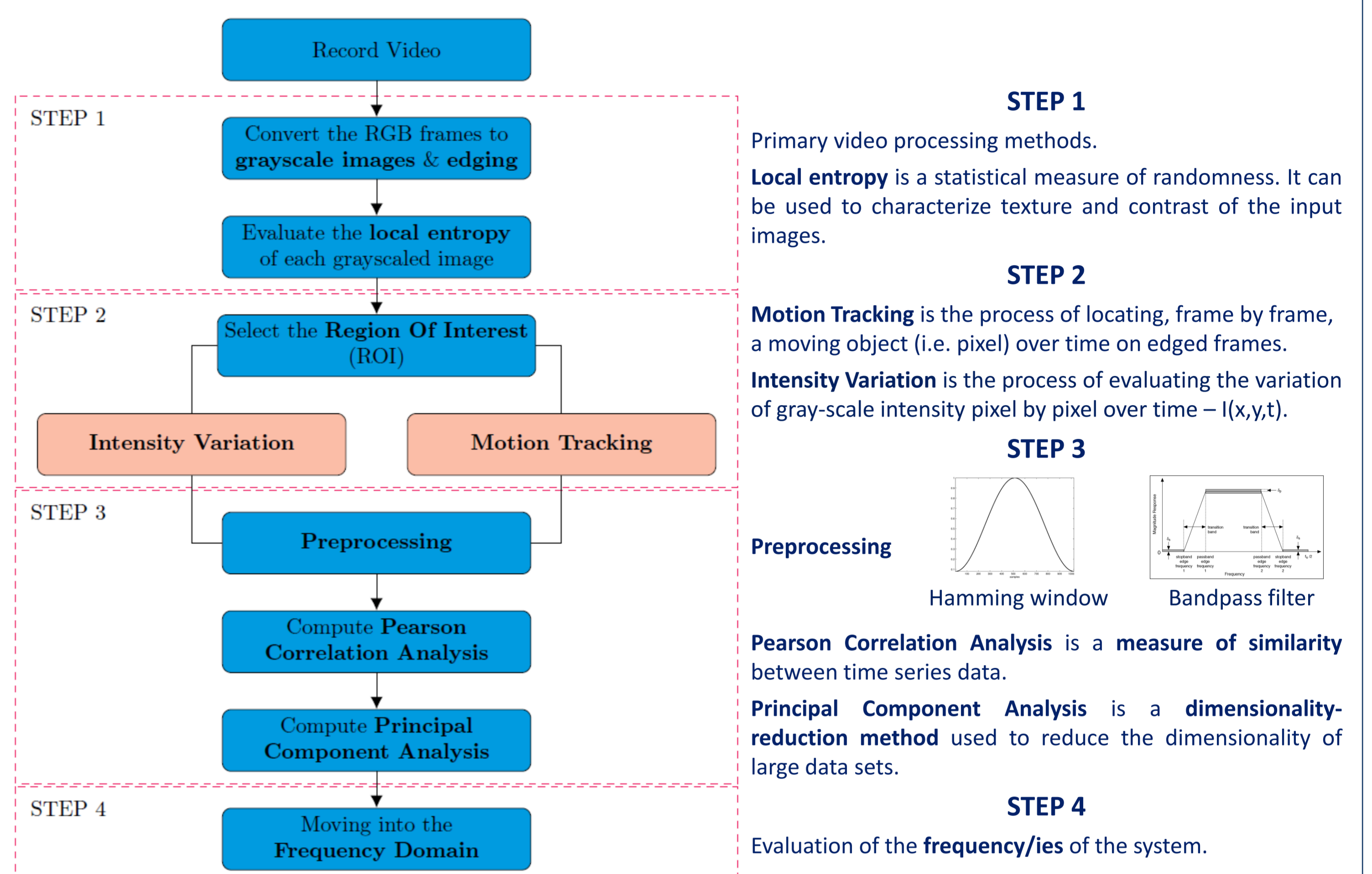
STRUCTURAL HEALTH MONITORING



Significant advantages of **vision sensors** include:

- ✓ low cost and ease of setup and operation
- ✓ non-contact, non-destructive, long distance
- ✓ flexibility to extract displacements of any point

COMPUTER VISION METHODOLOGY



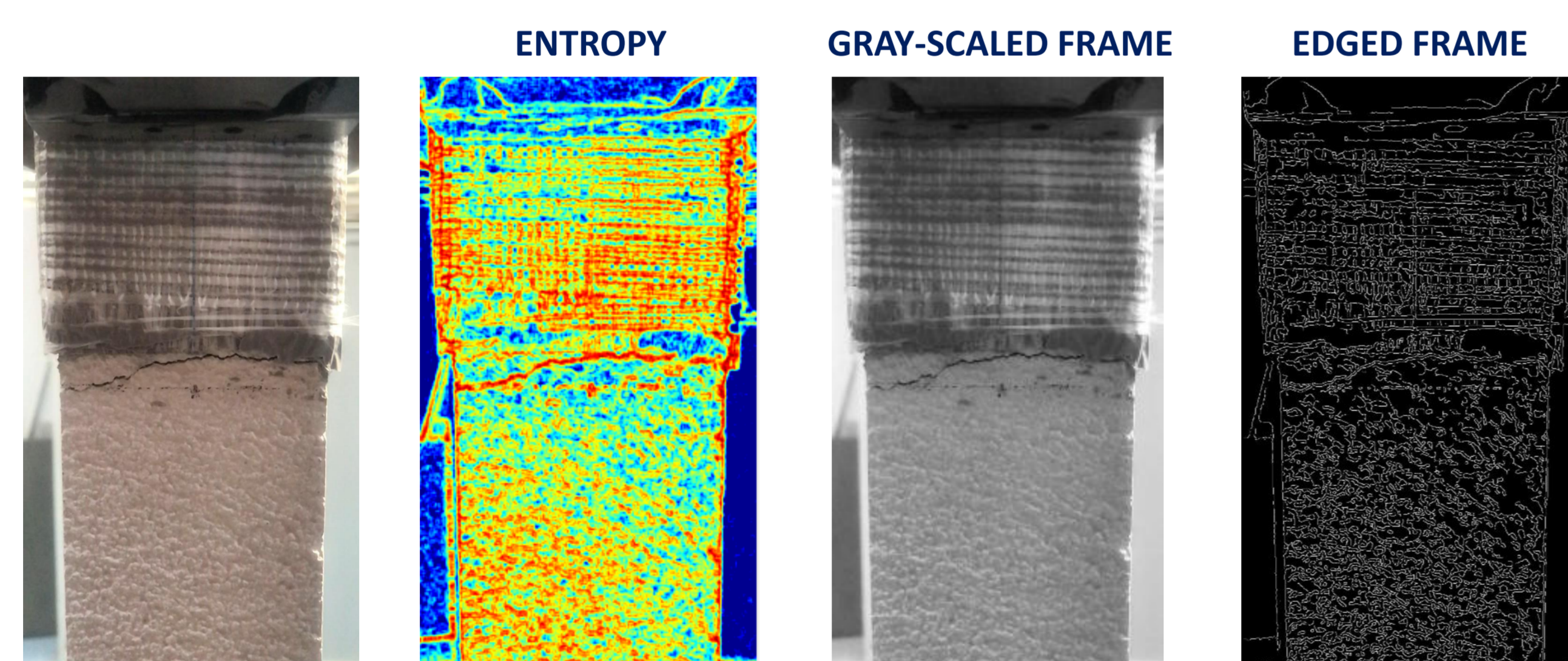
STUDY CASE 1

System: masonry column.

Fatigue test: the structure is subjected to a **constant frequency** at 10 Hz.

Video characteristics: duration = 7 seconds, frequency sampling = 30 Hz, number of frames = 210.

Frequency of the system: 10 Hz.



RESULTS STUDY CASE 1

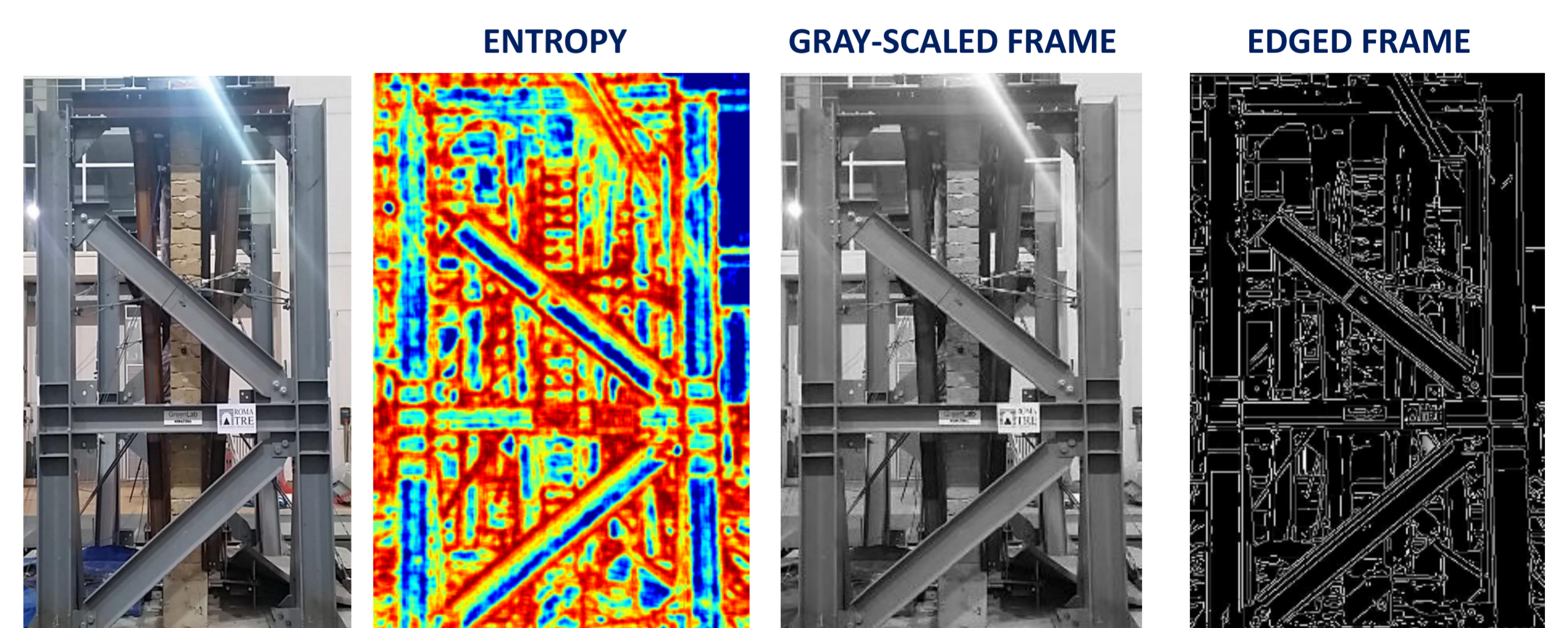
STUDY CASE 2

System: masonry wall.

Ambient Vibration Test: the structure is subjected to a **flat spectrum** on the frequency domain.

Video characteristics: duration = 120 seconds, frequency sampling = 30 Hz, number of frames = 3600.

Frequency of the system: 4.60 Hz, derived by traditional methods of system identification.



RESULTS STUDY CASE 2

STUDY CASES AND RESULTS

DEVELOPMENTS

One of the main concerns related to these applications is that laboratory test vibrations are still visible to the naked eye, even if they are characterized by a very small amplitude, while **ambient noise** induced vibrations of structures are imperceptible and the processing of the video recording "as is" might not provide representative results.

One possible solution to overcome this limitation can be found in the **magnification** of the original motion, adopting the pioneering procedure presented at MIT in 2015. It allows to magnify small displacements in video sequences, unveiling motions hardly visible. The combination of **Motion Magnification (MM)** and **Image Processing techniques** can be a very interesting and innovative approach to these problems.

Damage detection consists of monitoring the deviations and changes of a current system from its reference state. Those changes may involve materials, geometric properties, boundary conditions, and constraint configuration. The damage detection process is carried out through the periodic collection of measurements that allows the extraction of damage-sensitive features in order to establish the current state of the system. **Frequencies**, in particular, are susceptible to **variations in stiffness**, which could be caused by internal **damage**.

REFERENCES

- Feng D, Feng MQ. *Computer vision for SHM of civil infrastructure: From dynamic response measurement to damage detection – A review*. Engineering Structures 156 (2018) 105-117.
- De Canio G, de Felice G, et al. *Passive 3D motion optical data in shaking table tests of a SRG-reinforced masonry wall*. Earthquakes and Structures 10 (2016) 53-71.
- Kwan Oh B, et al. *Vision-based system identification technique for building structures using a motion capture system*. Journal of Sound and Vibration 356 (2015) 72-85.
- De Santis S, De Canio G, de Felice G, et al. *Out-of-plane seismic retrofitting of masonry walls with Textile Reinforced Mortar composites*. Bulletin of Earthquake Engineering 17 (2019) 6265-6300.
- Fioriti V, et al. *Motion Magnification Analysis for structural monitoring of ancient constructions*. Measurement 129 (2018) 375-380.
- Chen JC, Wadhwa N, et al. *Modal identification of simple structures with high-speed video using motion magnification*. Journal of Sound and Vibration 345 (2015) 58-71.

PUBLICATIONS AND WORKS

- Sangirardi M, Altomare V, de Felice G. *Analysis of the dynamic response of a masonry wall through computer vision and image processing techniques*. 10th Int. Conf. on Structural Health Monitoring of Intelligent Infrastructure (SHMII-10). Abstract accepted.